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# THE USE OF A VAPOR GENERATOR WITH DICHLORVOS TO CONTROL DROSOPHILA IN WINERIES

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CONTENTS



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The Shell Chemical Company supplied all of the insecticide used, conducted residue tests, and did some of the vapor analyses. The residue tests were made at Princeton, N. J., and the vapor analyses at Salida, Calif.

The Morse Laboratories of Sacramento, Calif., conducted most of the vapor analyses.

The Department of Food Science and Technology of Oregon State University conducted taste panel tests on the wine samples.

A. D Davison, Sanitarian of the Wine Institute, assisted in getting the cooperation of the wineries.




# THE USE OF A VAPOR GENERATOR WITH DICHLORVOS TO CONTROL DROSOPHILA IN WINERIES 1/

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## SUMMARY

A semiautomatic vapor generator to dispense insecticidal vapor from resin pellets containing 20-percent dichlorvos was tested for controlling drosophila in wineries. Preliminary tests showed that the machine could be operated successfully in wine cellars.

Use of the machine for 20 or 30 minutes on each of 5 consecutive days in a 161,284 cu. ft. cellar gave excellent control of drosophila. Two or three treatments per week for 9 weeks out of 14 considerably reduced the drosophila population in a 268,495 cu. ft. cellar. Mortalities for caged insects were: Drosophila, 97 percent; dried-fruit beetle, 54 percent; and pineapple beetle, 82 percent. Thirty pounds of pellets were used but were not enough for this cellar for an entire grape crushing season. On the basis of mortalities of caged drosophila, concentrations of less than 6 $\mu$g/cu. ft. were ineffective. One-half hour after the treatment, 9 percent of the dichlorvos had been lost from the air, and after 1 hour, 50 percent.

A taste panel found no off-flavor in wine that had been exposed uncovered to the vapor for 3 hours. Dichlorvos residues were less than 0.03 p.p.m., the sensitivity of the chemical method used. Tests of wines stored in covered wooden wine tanks during 15 dichlorvos treatments had similar results.

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1/ This study was made at the Dried Fruit and Tree Nut Insects Investigations, Fresno, Calif., a unit of the Stored-Product Insects Research Branch, Market Quality Research Division.

2/ Research entomologist, physical science technician, and agricultural research technician, respectively, Dried Fruit and Tree Nut Insects Investigations, Market Quality Research Division, Agricultural Research Service, U. S. Department of Agriculture, Fresno, Calif. 93727.

Daily treatments with the vapor generator in wine cellars would effectively control drosophila, but adjustments in operating time would have to be made periodically.

## BACKGROUND

Drosophila spp., or vinegar flies, are the most serious pests infesting wineries; the dried-fruit beetle, Carpophilus hemipterus (Linnaeus) is probably the second most common insect.

Tests conducted in wineries since 1961 using dichlorvos in thermal aerosol treatments have shown that this compound is quite effective in controlling drosophila. 3/ Laboratory tests conducted by Jay and others 4/ showed that concentrations of 0.28 μg/cu. ft. (0.01 μg/liter) produced a 95-percent mortality of adult drosophila in 185.6 minutes.

The heaviest drosophila infestations coincide with the peak of the grape crushing season. All winery personnel are extremely busy during this 2-month period. A semiautomatic insect-control system should, therefore, be of considerable interest to operators of a winery. This paper describes tests of a semiautomatic generator to dispense dichlorvos vapor for insect control.

The vapor dispenser first used in wineries in 1964 (table 1) for three preliminary tests was designed to test the general suitability of the vapor generator to wine cellar operations. Five additional tests (table 2) were made in 1965, to test the effectiveness of short daily periods of vapor generation for continuing insect control in wineries. In 1966, the machine was operated during about 3 months to determine the effectiveness of the vapor generator under actual conditions for an entire grape crushing season (tables 3 and 4).

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3/ Yerington, Albert P. Control of Drosophila in Wineries with Dichlorvos Aerosols. Jour. Econ. Entomol. 60(3): 701-704. 1967.

4/ Jay, Edward G., Phillip K. Harein, and Hagen B. Gillenwater. The Toxicity of Dichlorvos in Air to Adult Drosophila melanogaster. Jour. Econ. Entomol. 57(3): 413. 1964.

## PROCEDURE

One cellar in each of two wineries was used for all tests. Both wineries were located within 2 miles of the laboratory at Fresno, Calif., in the northeastern section of the city. Both cellars were similarly constructed with brick walls and wooden roofs. Both had screened windows, but the screens in the large cellar did not keep the vinegar flies outside. Doors in both cellars were occasionally left open for the passage of hoses used in unloading the wine tanks.

The smaller cellar, used in 1964 and 1965, contained 29 closed wooden wine tanks with capacities varying from 1,000 to 32,000 gallons of wine. It contained 161,284 cu. ft. of air space. The larger cellar, used in 1964 and 1966, contained 32 closed wooden wine tanks, each tank capable of holding 50,000 gallons of wine. This cellar contained 268,495 cu. ft. of air space.

The semiautomatic vapor generator that dispenses the dichlorvos was developed by the Stored-Product Insects Research and Development Laboratory at Savannah, Ga. 5/ This machine produced dichlorvos vapors by heating 30 pounds of resin pellets impregnated with 20-percent dichlorvos. A fan increased the dispersal of the vapor. The machine was operated at a temperature of 120 ± 5° F. The airflow regulator was set at a pressure of 0.5 inch of water.

The vapor generator was operated from 1 to 1 1/2 hours during each test in 1964. During the first and second tests, it was operated from several locations at one end of the cellar. However, the experimenters decided that the machine would perform efficiently from one location, and all subsequent tests were made in this manner.

Insect cages were located in the four corners of the cellar 6 feet or 24 feet above the floor. In the first and second tests, an additional cage was placed 24 feet above the floor on top of a wine tank in the center of the cellar.

In the 1965 test, the machine was placed at one end of the smaller cellar. The stream of vapor was directed down the center aisle. The generator was operated for 20 or 30 minutes on 5 consecutive days. Cages of insects were used in this test also.

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5/ Gillenwater, Hagen B., and Phillip K. Harein. A Dispenser Designed to Provide Large Quantities of Insecticide Vapor. Jour. Econ. Entomol. 57(5): 762-764. 1964.

In the 1966 test, the vapor generator was operated under actual working conditions in the larger cellar. Trapping records had indicated that this cellar had a more severe infestation problem than did the smaller one. During operation, the generator was 6 feet above the floor at one end of the cellar. The test covered a period of 14 weeks, but no treatments were made during the 1st, 6th, and 11th weeks for the purpose of comparing trap catches. The total number of hours the generator was operated per week was gradually increased from 2 1/2 to 20 1/2 (table 3). Treatments were made twice a week for the first 5 weeks of operation, three times a week for the next 4 weeks, and daily for the last 2 weeks.

Three methods were used to evaluate the results of the vapor generator tests. The first method was by using drosophila traps 6/ made of pint or quart jars baited with dried figs, yeast, and water. A cheesecloth and paper basket fitted into the neck of the jar prevented the flies from reaching the bait. A few drops of dichlorvos, placed in the basket to kill the insects, made counting easier. Traps were examined three times weekly in 1964, and daily except weekends in 1965 and 1966. Dead flies from the traps were taken to the laboratory and counted. Fresh traps were put out at weekly intervals. In the larger cellar, a trap was placed at each end. Controls were single traps in two other cellars that were not treated. In the smaller cellar only one trap was used, and another trap in a small room used as a cellar was the control.

Trap counts were used in various ways to evaluate the tests. Counts made before treatments and during weeks that treatments were not made served for comparison. Ratios between numbers of trapped flies in treated and untreated areas were also used. Another use of the trap counts was to determine when treatments were needed and if they had been effective. A trap count of more than 25 drosophila per day per trap was taken to indicate that an area should be treated. Also, after a treatment, the day a single trap count exceeded 25 flies, the treatment was deemed ineffective at that time.

The second method of evaluation was by the mortality of caged insects placed in the cellar during treatments. Cages were made of 40-mesh stainless steel wire screen molded into a 3/4-by 3-inch tube with a cork stopper at both ends. Cages were exposed only when the vapor generator was operating. One cage was placed in an untreated cellar as a control.

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6/ Yerington, A. P., and R. M. Warner. Flight Distances of Drosophila Determined with Radioactive Phosphorus. Jour. Econ. Entomol. 54(3): 425-428. 1961.

During the 3 years of testing, three to seven cages, each containing about 50 adult Drosophila melanogaster Meigen, were placed in each cellar for each treatment. In the 1965 and 1966 tests, three cages of 20 adult dried-fruit beetles, Carpophilus hemipterus (Linnaeus), were also used. In the 1966 test, three cages of adult pineapple beetles, Urophorus humeralis (Fabricius) were added to each test. All the insects used in the cage tests were reared in the laboratory from populations that had been field-collected the previous year.

Immediately after the vapor generator was turned off, caged insects were removed from the treated area and brought to the laboratory. Mortality counts were made on the drosophila about 1 hour after the test. The dried-fruit beetles and pineapple beetles were placed in a petri dish with a little food. Mortality counts were made 12 hours after the test.

The third method of evaluation was by chemical analysis of vapor samples. Air samples were taken with a unit devised by the U.S. Public Health Service at Savannah, Ga. 7/ The unit consists of two medium-sized scrubber impingers attached in tandem to a vacuum pump equipped with a regulating valve, a vacuum gage, and a gas meter. Samples collected in the water-filled impingers were taken immediately to the laboratory, where the dichlorvos was extracted from the water by the addition of methylene chloride. Samples were refrigerated until shipped for analysis. The samples were analyzed either by the Shell Agricultural Research Center at Salida, Calif., or by Morse Laboratories at Sacramento, Calif. One air sample was taken before each treatment, one or more immediately after the generator had stopped operating, and occasionally another sample 24 hours after the application.

Samples of wine were analyzed for dichlorvos residues by the Shell Chemical Company Product Development Center, Princeton, N. J. Flavor tests were made by the Department of Food Science and Technology, Oregon State University, Corvallis. Some of the samples of tokay and sherry wines had been stored in closed wine tanks through 15-vapor generator treatments. Other samples of the same two types of wine had been exposed for 3 hours in open beakers 15 feet in front of the operating vapor generator.

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7/ See footnote 3.

## RESULTS

1964 tests.--Very good results of the treatments are shown in table 1. Vapor concentrations at 2 ft. and 14 ft. above the floor in the center of the cellar never exceeded the 28 $\mu$g/cu. ft. accepted as the threshold limit of safety for workers in a treated area by the American Conference of Governmental Industrial Hygienists. Vapor concentrations were lower in the third test, since this cellar had almost twice the amount of air space as the first cellar and it also had a few open windows. Readings were very low after 24 hours.

In the first test, mortalities of caged drosophila in seven locations ranged from 88 to 100 percent, with an average of 95 percent. Mortalities were 100 percent in all locations in the second and third tests. Insects survived only at locations 24 feet above the floor.

The results of the 1964 tests indicated that it would be advantageous to use the vapor generator in wine cellars.

1965 tests.--The short daily treatments made with the vapor generator in 1965 gave good results (table 2). The tests were made in the smaller cellar.

During the third day of operation, $CO_2$ that drifted into the cellar from a nearby fermentation room may have increased the mortality of the drosophila in the cellar and cages, since they are very susceptible to carbon dioxide. Cages of dried-fruit beetles were used the last 2 days instead of drosophila since they are not as susceptible to $CO_2$. However, no $CO_2$ was detected during these days. Trap counts of drosophila remained low during the entire period, and vapor concentration readings were at a very safe level.

1966 tests.--The effect of vapor generator treatments for an entire season on drosophila populations inside a wine cellar is shown in table 3. After the first several weeks, significantly fewer flies were trapped in the treated area than in the untreated areas. Although the trap counts indicated a gradual buildup of flies in untreated areas, populations remained constantly low in the treated area. Although the highest daily trap catch remained fairly low, a rather rapid reduction in the amounts of dichlorvos produced by the vapor generator occurred (table 4).

The generator did not maintain its early rate of vapor production. There was approximately a four-fifths loss in amounts of dichlorvos vapors produced after only 17 1/2 hours of operation. After 61 hours of operation, vapor concentrations produced in the wine cellar by 2 hours of operation were approximately 5 $\mu$g/cu. ft., compared with 48 to 56 $\mu$g/cu. ft. during the first hours of operation. Part of the rapid decline in vapor production may have been caused by the deterioration of the pellets by constant exposure to air. The cover of the generator remained off during the entire period of operation.

Table 4 also showed that even as the vapor concentrations dropped, they were still high enough at all times to cause high mortalities to caged drosophila. The lowest mortality recorded was 85 percent. The lowest mortalities recorded for caged pineapple beetles were 26 percent and 41 percent, both recorded during the last 2 weeks of operation. Mortalities for caged dried-fruit beetles for the same period were 5 and 22 percent. These were also the lowest mortalities recorded for this insect. Concentrations of dichlorvos ranged from 6.9 to 4.6 $\mu$g/cu. ft. during these last 2 weeks and the generator was operated on a daily basis to maintain effective control of drosophila in the cellar. Higher concentrations of dichlorvos than most of those reported here would be required if the dried-fruit beetle were also a serious pest in the cellars. It should be remembered, however, that the caged insects were exposed only for the time the vapor generator was in operation, and the vapor concentration readings were made at the time the generator was turned off and directly in front of the machine.

A single test was conducted in 1966 to find how rapidly the dichlorvos vapors disappear from the air after the generator has been turned off (table 5). The original dichlorvos concentration of 4 $\mu$g/cu. ft. is possibly a little low to give a good picture of the dispersal rate, but the concentrations being given off by the generator were not known until the samples were analyzed later. One-half hour after the treatment, 9 percent of the dichlorvos had been lost from the air, and after 1 hour, 50 percent.

Dichlorvos concentrations measured 3 hours after each treatment during the last four tests of the 1966 season are shown in table 6. The average loss in these four tests at 3 hours is higher than in the single test at 4 hours.

The taste panel conducted in 1966 by the Food Science and Technology Department of Oregon State University found no off-flavor in either sherry or tokay wines stored in covered wooden wine tanks for 15 treatments or exposed directly to the vapor for 3 hours. The 15 treatments included 33 hours' operation of the generator, with vapor concentrations from 4 to 56 $\mu$g/cu. ft. being recorded after individual treatments. Air concentrations at the end of the 3-hours operation of the vapor generator measured 8 $\mu$g/cu. ft. where the wine was exposed in open beakers.

Residue tests made on the same samples mentioned above showed that residues of dichlorvos were less than 0.03 p.p.m., or below the range of sensitivity of the analytic method.

## CONCLUSIONS

The use of a vapor generator with dichlorvos would require less manpower than that for the daily thermal aerosol treatments. But the method loses some of its automatic advantages since it has to be adjusted periodically to control the dichlorvos output. To maintain effectiveness, it would still be necessary to increase the daily operating time as the season progresses. The increase necessary could be determined by visual observations or by the use of traps.

Since the automatic features of the vapor generator are among the most important characteristics of the machine, to set the machine to operate on a daily basis would be more desirable. Applications of dichlorvos at daily intervals were more effective against drosophila than less frequent applications, except when low concentrations were being produced by the generator. One filling of the chamber with 30 pounds of pellets does not seem to be sufficient for the entire grape crushing season in a cellar of this size.

Since this machine was tested, the vapor generator has been remodeled. Preliminary tests made with the new machine indicate that its performance will be very similar to that of the old machine under conditions like those in this experiment.

Table 1.--Dichlorvos vapor concentrations and mortality of drosophila resulting from three preliminary tests of a vapor generator in two wineries in 1964

| Location and date | Generator operated | Mortality of caged drosophila located in-- NW corner | NE corner | SW corner | SE corner | Center[1] | Vapor concentrations: Center at 2 ft. | Center at 14 ft. |
|---|---|---|---|---|---|---|---|---|
| | Hours | Percent | Percent | Percent | Percent | Percent | µg./cu. ft. | µg./cu. ft. |
| Winery No. 1[2]: | | | | | | | | |
| Oct. 13 | 1 | 100 | 100 | 100 | 100 | [3] 88 | [4] 7.3 | 18.4 |
| 14 | -- | -- | -- | -- | -- | -- | 0.2 | 0.5 |
| Oct. 22 | 1-1/2 | 100 | 100 | 100 | 100 | 100 | 13.2 | 22.2 |
| 23 | -- | -- | -- | -- | -- | -- | -- | 1.4 |
| Winery No. 2[5]: | | | | | | | | |
| Nov. 15 | 1-1/2 | 100 | 100 | 100 | 100 | -- | 5.8 | 5.6 |
| 16 | -- | -- | -- | -- | -- | -- | 0.1 | 1.1 |

[1] Cage located 24 ft. above floor, all others at 6 ft.

[2] Cellar contains 161,284 cu. ft. air space.

[3] Additional cages: NW at 24 ft. = 91 percent, SE at 24 ft. = 88 percent.

[4] Sensitivity of chemical analysis is 0.03 µg./cu. ft.

[5] Cellar contains 268,495 cu. ft. air space.

Table 2.--Dichlorvos vapor concentration, insect trap catches, and insect mortalities resulting from operation of a vapor generator for short periods on 5 successive days in 1965

| Time of treatment | Vapor concentrations: Before | Vapor concentrations: After | Operation time | Trap catch: Treated area | Trap catch: Untreated area | Cage tests: Average mortalities[1] |
|---|---|---|---|---|---|---|
| | μg./cu. ft. | μg./cu. ft. | Min. | No. | No. | Percent |
| First day | 0.2 | 5.7 | 30 | [2] 62 | 665 | [3] 100 |
| Second day | 0.4 | 6.1 | 30 | 0 | 132 | [3] 100 |
| Third day | 0.1 | 3.7 | 20 | 1 | 505 | [3] 100 |
| Fourth day | 0.3 | 4.1 | 20 | 1 | 826 | [4] 62 |
| Fifth day | -- | 5.8 | 30 | 4 | 300 | [4] 100 |
| 24 hr. after final treatment | 0.56 | -- | -- | 6 | 1,260 | -- |
| 48 hr. after final treatment | -- | -- | -- | 18 | 500 | -- |

[1] Average of 2 cages.

[2] Counts made before treatment.

[3] Adult Drosophila.

[4] Adult dried-fruit beetle.

Table 3.--Trap catches of drosophila resulting from a series of vapor generator treatments using dichlorvos in a wine cellar in 1966

| Week | Treatments | Time operated/ week | Drosophila trap catch[1/] | | Highest daily trap catch[2/] | | Proportion of treated to untreated drosophila |
|---|---|---|---|---|---|---|---|
| | | | Treated area | Untreated area | Treated area | Untreated area | |
| | Number | Hours | Number | Number | Number | Number | |
| July 26 - Aug. 2 | 0 | 0 | 2,789 | 43 | 992 | 17 | 1 to 0.1 |
| Aug. 3 - Aug. 9 | 2 | 2.5 | 818 | 1,498 | 241 | 430 | 1 to 1.8 |
| Aug. 10 - Aug. 16 | 2 | 3.0 | 1,348 | 5,389 | 504 | 1,688 | 1 to 4.0 |
| Aug. 17 - Aug. 23 | 2 | 4.0 | 339 | 2,966 | 185 | 936 | 1 to 8.8 |
| Aug. 24 - Aug. 30 | 2 | 4.0 | 149 | 5,987 | 50 | 1,744 | 1 to 40.2 |
| Aug. 31 - Sept. 6 | 0 | 0 | 1,054 | 4,513 | 528 | 1,360 | 1 to 4.3 |
| Sept. 7 - Sept. 13 | 2 | 4.0 | 137 | 2,801 | 50 | 585 | 1 to 20.4 |
| Sept. 14 - Sept. 20 | 3 | 5.5 | 195 | 4,154 | 57 | 1,290 | 1 to 21.3 |
| Sept. 21 - Sept. 27 | 3 | 7.0 | 234 | 5,848 | 75 | 1,050 | 1 to 25.0 |
| Sept. 28 - Oct. 4 | 3 | 9.0 | 212 | 6,637 | 49 | 1,500 | 1 to 31.3 |
| Oct. 5 - Oct. 11 | 0 | 0 | 760 | 6,565 | 256 | 1,800 | 1 to 8.6 |
| Oct. 12 - Oct. 18 | 3 | 8.5 | 184 | 7,043 | 69 | 1,500 | 1 to 38.3 |
| Oct. 19 - Oct. 25 | 7 | 13.5 | 104 | 3,126 | 29 | 665 | 1 to 30.1 |
| Oct. 26 - Nov. 1 | 7 | 20.5 | 47 | 1,994 | 11 | 667 | 1 to 42.4 |

1/ Totals for 2 traps.

2/ Single trap.

Table 4.--Amounts of dichlorvos applied and mortalities of 3 species of caged insects during vapor generator tests in a wine cellar in 1966

| Week | Treatments | Total time operated | Dichlorvos: First treatment | Dichlorvos: Second treatment | Total dichlorvos[1] for week | Mortalities of cage insects: Drosophila[2] | Mortalities of cage insects: Dried-fruit beetle[3] | Mortalities of cage insects: Pineapple beetle[3] |
|---|---|---|---|---|---|---|---|---|
| | Number | Hours | µg./cu. ft. | µg./cu. ft. | µg./cu. ft. | Percent | Percent | Percent |
| July 26 - Aug. 2 | 0 | 0.0 | | | | | | |
| Aug. 3 - Aug. 9 | 2 | [4] 2.5 | 56.0 | 48.0 | 104.0 | 100 | 88 | 98 |
| Aug. 10 - Aug. 16 | 2 | 5.5 | 56.0 | 51.0 | 107.0 | 100 | 85 | 97 |
| Aug. 17 - Aug. 23 | 2 | 9.5 | 36.0 | -- | 72.0 | 100 | 96 | 100 |
| Aug. 24 - Aug. 30 | 2 | 13.5 | -- | 16.4 | 32.8 | 99 | 63 | 97 |
| Aug. 31 - Sept. 6 | 0 | 0.0 | | | | | | |
| Sept. 7 - Sept. 13 | 2 | 17.5 | 19.0 | 11.5 | 30.5 | 100 | 62 | 96 |
| Sept. 14 - Sept. 20 | 3 | 23.0 | -- | 10.2 | 30.8 | 100 | 37 | 89 |
| Sept. 21 - Sept. 27 | 3 | 30.0 | 4.0 | 11.8 | 23.2 | 100 | 46 | 93 |
| Sept. 28 - Oct. 4 | 3 | 39.0 | 8.0 | 6.8 | 22.1 | 95 | 55 | 69 |
| Oct. 5 - Oct. 11 | 0 | 0.0 | | | | | | |
| Oct. 12 - Oct. 18 | 3 | 47.5 | 5.5 | 3.2 | 13.1 | 99 | 40 | 92 |
| Oct. 19 - Oct. 25 | 7 | 61.0 | 6.9 | 4.5 | 35.1 | 85 | 5 | 26 |
| Oct. 26 - Nov. 1 | 7 | 81.5 | 4.8 | 4.6 | 33.1 | 88 | 22 | 41 |
| Average | -- | -- | -- | -- | -- | 97 | 54 | 82 |

[1] Actual readings for 2 operations plus estimated for other treatments.

[2] Average of 5 locations.

[3] Average of 3 locations.

[4] Times shown are cumulative.

Table 5.--Loss of dichlorvos vapor concentrations from a wine cellar at intervals after treatment by a vapor generator

| Hours after treatment | Dichlorvos | Loss of original concentration |
|---|---|---|
| | μg./cu. ft.[1/] | Percent |
| Before | 0.14 | -- |
| 0 [2/] | 4.00 | 0 |
| 1/4 | 4.00 | 0 |
| 1/2 | 3.63 | 9 |
| 1 | 2.00 | 50 |
| 2 | 1.63 | 59 |
| 4 | 1.38 | 66 |
| 6 | .68 | 83 |
| 8 | .58 | 86 |
| 24 | .13 | 97 |

[1/] Not corrected for controls.

[2/] Reading at time generator was turned off.

Table 6.--Concentrations and losses of dichlorvos vapors in a wine cellar 3 hours after treatments[1/] with a vapor generator

| Test Number | Concentrations at end of treatment | Concentrations after 3 hours | Loss after 3 hours |
|---|---|---|---|
| | μg./cu. ft. | μg./cu. ft. | Percent |
| 1 | 6.9 | 0.6 | 91 |
| 2 | 4.5 | 1.3 | 72 |
| 3 | 4.8 | 1.0 | 79 |
| 4 | 4.6 | 0.6 | 87 |
| Average | -- | -- | 82 |

[1/] Treatments made October 17-27, 1966.